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U1S S1754 S1840

(56) Documents cited
GB 2189363 A GB 1401273 A EP 0162351 A2
WO 88/08544 A US 4771290 A

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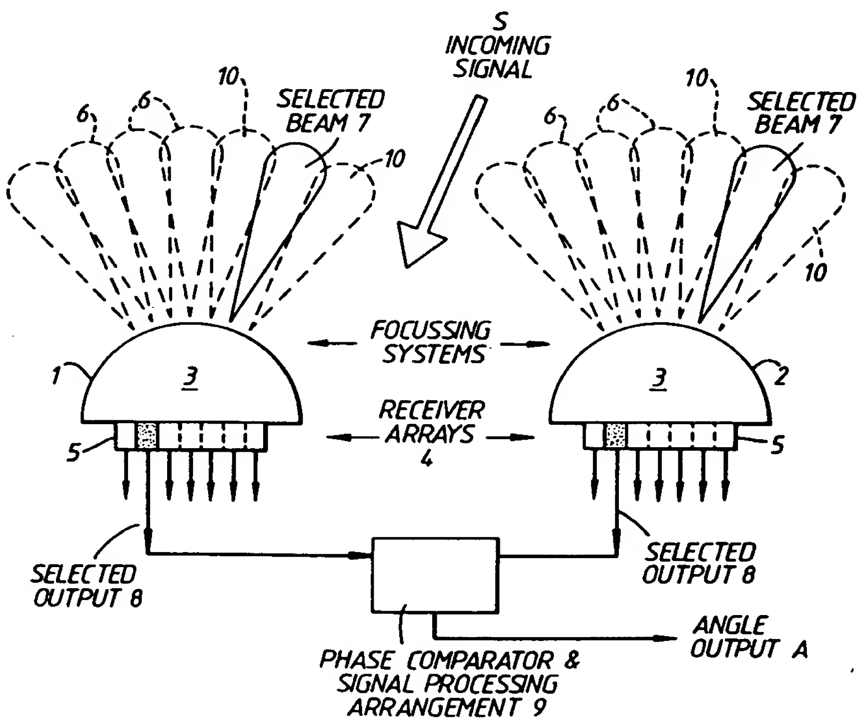
INT CL[5] G01S
Online databases WPI, CLAIMS, INSPEC

(54) **Interferometers**

(57) To determine the angle of arrival of an incoming signal S, the direction finder comprises two spaced apart multibeam receiver arrays 4, the determination of the angle of arrival being carried out in three stages, first, by determining which of the beams 6 of each of the arrays 4 receives the largest amplitude signal, second, by comparing the relative phases of the signals received in the selected beam 7 of each of the arrays 4 and third by comparing the selected output 8 with the output from adjacent beams in either of the arrays, thus interpolating between the signal received in the selected beam 7 with signals received in adjacent overlapping beams 10 to resolve phase ambiguity.

The interferometer is used in either passive or active radar mode, e.g. for landing guidance.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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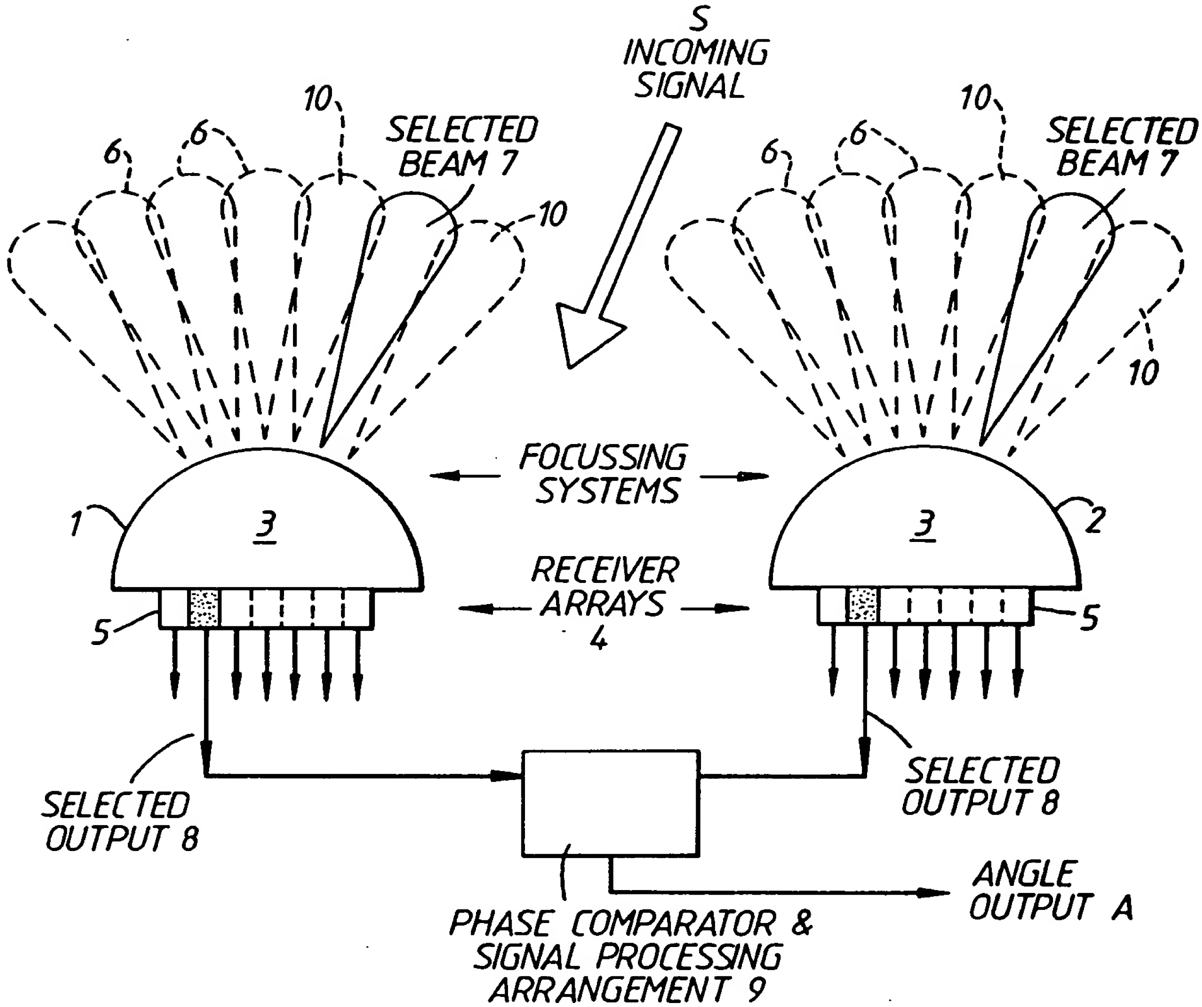
S
INCOMING
SIGNAL
10
6
6
SELECTED
BEAM 7
10
10
FOCUSSING
SYSTEMS
1
3
3
2
RECEIVER
ARRAYS
4
5
5
SELECTED
OUTPUT 8
SELECTED
OUTPUT 8
ANGLE
OUTPUT A
PHASE COMPARATOR &
SIGNAL PROCESSING
ARRANGEMENT 9

Interferometers

This invention relates to interferometers and relates more especially to an interferometer for estimating the angle of arrival of an incoming radio frequency signal. The interferometer may operate in either a passive mode, where the signal is from an external source, or in an active mode, for example, as part of a radar system, when used together with a transmitter.

A conventional interferometer can provide a highly accurate, but ambiguous, estimate of the angle of arrival of an incoming signal. Methods of resolving the ambiguities as reported in the open literature are generally either mechanically complex, for example, using multiple baseline interferometers - see an article entitled "Ambiguity Resolution in Interferometry" by Jacobs E. and Ralston E., published in IEEE Transactions Aero. Elec. Systems, November 1981, or operate over a limited instantaneous field of view, for example, using a monopulse receiver to resolve ambiguities - see an article "Monopulse Resolution of Interferometric Ambiguities" by Dybdal R., published in IEEE Transactions Aero. Elec. Systems, March 1986.

It is an object of the present invention to provide an improved form of interferometer which overcomes some of the disadvantages of known interferometers.

According to one aspect of the present invention there is provided an interferometer for estimating the angle of arrival of an incoming signal comprising two multibeam receiver arrays which are separated along a baseline for receiving said incoming signal, and processor means operable on the outputs of said arrays for affording an output indicative of said angle.

In a preferred arrangement according to the aforesaid one aspect, said processor means will comprise means for determining which beam of each of said arrays receives the largest amplitude signal to derive a coarse angle of arrival of said incoming signal, means for comparing the relative phases of the signals received in the determined beam of each of said arrays to derive a fine angle of arrival of said received signal, and means for comparing the signal in the determined beam of one of said arrays with received signals in adjacent overlapping beams thereof for resolving phase ambiguities in said derived fine angle of arrival of said incoming signal.

In carrying out the preferred arrangement it may be arranged that each of said multibeam receiver arrays takes the form of a focal plane system typically comprising focussing means for receiving said incoming signal, a linear array of receiving elements disposed substantially at the focal surface of said focussing means, and local oscillator means for forming a multibeam receiver output.

Advantageously, said means for comparing the signal in the determined beam of one of said arrays with received signals in adjacent arrays, comprises a look-up table arrangement.

According to another aspect of the present invention there is provided a method for estimating the angle of arrival of an incoming signal comprising the steps of providing two multibeam receiver arrays which are separated along a baseline for receiving said incoming signal, determining which beam of each of said arrays receives the largest amplitude signal to derive a coarse angle of arrival of said incoming signal, comparing the relative phases of the signals received in the determined beam of each of said arrays to derive a fine angle of arrival of said incoming signal, and comparing the signal in the determined beam of one of said arrays with received signals in adjacent

overlapping beams thereof for resolving phase ambiguities in said derived fine angle of arrival of said incoming signal.

An exemplary embodiment of the invention will now be described reference being made to the accompanying single figure drawing which is a block schematic diagram of a multibeam interferometer in accordance with the present invention.

The multibeam interferometer shown in the drawing comprises two multibeam receiver arrays 1 and 2 each constituted by a focal plane system comprising a focussing system 3, typically a reflector or lens, an array 4 of receiver elements 5 which lie at or close to the focal surface of the focussing system 3, and a local oscillator (not shown). In the embodiment shown in the drawing, each array 4 comprises seven receiver elements 5 so that the field of view of each array 4 is constituted by seven directional beams 6, each corresponding to one of the receiver elements 5. The field of view of the system may be increased by increasing the number of receiving elements 5, provided the focussing system 3 does not introduce significant beam distortions towards the edges of the field of view. Such focal plane systems are well known and are simple in concept and tend to be mechanically robust.

Further information on such systems can be found in an article entitled "MMW Radio-Astromonical Imaging Instrumentation" by Sigfrid Yngvesson K., in Microwave System News (MSN), December 1988; in an article entitled "Printed Dipole - Schottky Diode Millimeter Wave Antenna Array" by Parrish P.T. et al, in SPIE Vol. 337 Millimetre Wave Technology, 1982; and in an article entitled "Microwave & Millimetrewave Staring Array Technology" by Alder C.J. et al, in Proc. 20th European Microwave Conf., September 1990.

In the multibeam interferometer shown in the drawing, the angle of arrival of an incoming signal S is estimated in three stages.

First, the coarse angle of arrival of the signal S is determined by selecting for each of the arrays 4 the receiver element 5, and hence the beam 6, that contains the largest amplitude signal, the selected beams being referenced 7. Second, the fine angle of arrival of the signal S is determined by interferometry from the relative phase between the selected outputs 8 from the selected receiver elements 5 from the arrays 4, these being applied to a phase comparator and signal processing arrangement 9 which affords an angle output signal A. In the example shown in the drawing, the incoming signal S will be received

by the right hand side array 4 before the left hand side array, the phase difference between the two received signals being dependent upon the angle of arrival of the incoming signals. Third, any phase ambiguities which may exist are resolved using interpolation techniques to compare the selected output 8 from either one of the arrays 4 with outputs corresponding to received signals in adjacent overlapping beams, such as the beams 10. This interpolation may be carried out using, for example, a look-up table which forms part of the phase comparator and signal processing arrangement 9, and which lists the relative outputs from the selected beam 7 and the adjacent overlapping beams 10 and specifies the corresponding angle of arrival of the incoming signal S, or by comparing the ratios of the outputs from the selected beams 7 and the overlapping beams 10, thereby enabling spurious signals to be disregarded.

It will be appreciated that the selection and processing of the selected outputs 8 from the arrays 4 in accordance with the three stages set out above, may be carried out using hardware or software techniques.

As has been mentioned, the multibeam interferometer which has been described may be used in a passive mode, where the incoming signal is from an external source, or in

an active mode, for example, as part of a radar system where the incoming signal is a reflected radar signal from a radar transmitter.

A typical application for a multibeam interferometer as described might be for helicopter landing guidance on an oil rig, where high accuracy angular approach information in both azimuth and elevation is required. In this application the helicopter might carry a transmitter whose bearing from the oil rig could be measured by a multibeam interferometer on the rig.

In comparison with prior art interferometers, the multibeam interometer which has been described offers the advantages of:

1. Simpler and more robust mechanical construction than a multiple baseline interferometer, possibly based on focal plane technology;

2. Wider instantaneous field of view than an interferometer with a monopulse receiver, where the field of view is set by the width of a beam and the number of beams; and

3. Operation in a multisignal environment - which not all interferometers can do - provided the signals are separated in angle by more than one beam width so that they lie in different beams.

CLAIMS

1. An interferometer for estimating the angle of arrival of an incoming signal comprising two multibeam receiver arrays which are separated along a baseline for receiving said incoming signal, and processor means operable on the outputs of said arrays for affording an output indicative of said angle.

2. An interferometer as claimed in claim 1, in which said processor means comprises means for determining which beam of each of said arrays receives the largest amplitude signal to derive a coarse angle of arrival of said incoming signal, means for comparing the relative phases of the signals received in the determined beam of each of said arrays to derive a fine angle of arrival of said incoming signal, and means for comparing the signal in the determined beam of one of said arrays with received signals in adjacent overlapping beams thereof for resolving phase ambiguities in said derived find angle of arrival of said incoming signal.

3. An interferometer as claimed in claim 1 or claim 2, in which each of said multibeam receiver arrays takes the form of a focal plane system.

4. An interferometer as claimed in claim 3, in which each of said focal plane system comprises focussing means for receiving said incoming signal, a linear array of receiving elements disposed substantially at the focal surface of said focussing means, and local oscillator means for forming a multibeam receiver output.

5. An interferometer as claimed in any preceding claim, in which said means for comparing the signal in the determined beam of one of said arrays with received signals in adjacent arrays, comprises a look-up table arrangement.

6. A method for estimating the angle of arrival of an incoming signal comprising the steps of providing two multibeam receiver arrays which are separated along a baseline for receiving said incoming signal, determining which beam of each of said arrays receives the largest amplitude signal to derive a coarse angle of arrival of said incoming signal, comparing the relative phases of the signals received in the determined beam of each of said arrays to derive a fine angle of arrival of said incoming signal, and comparing the signal in the determined beam of one of said arrays with received signals in adjacent overlapping beams thereof for resolving phase ambiguities in

said derived fine angle of arrival of said incoming signal.

7. A multibeam interferometer substantially as hereinbefore described with reference to the accompanying drawing.

8. A method for estimating the angle of arrival of an incoming signal substantially as hereinbefore described with reference to the accompanying drawing.

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Relevant Technical fields

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(ii) Int Cl (Edition 5) G01S

Search Examiner

G A McLEAN

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES WPI, CLAIMS, INSPEC

Date of Search

25 FEBRUARY 1991

Documents considered relevant following a search in respect of claims 1 - 8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X, Y	GB 2,189,363 A (PHILIPS) - especially line 56, page 3 - line 36, page 5	1, 2, 6
X	GB 1,401,273 A (COSSOR) - whole document	1
X, Y	EP 0,162,351 A2 (FUJITSU) - especially pages 3, 5, 9	1, 2, 6
Y	WO88/08544 (SUNDSTRAND) - especially line 18, page 13 - line 22, page 14	"
X, Y	US 4,771,290 (BOEING) - whole document	"

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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